Oil for a Sustainable Biodiesel World

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AGENDA

- Sustainability
- New Oil Supply

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Sustainable Feedstock Concepts

- Sustainability
  - Ensure long term survival of the species
  - Maintain and improve quality of life
  - Minimize harm from production
    - People, livestock, environment
  - Make rational business decisions
  - Ensure continuous improvement
- Sustainable Biodiesel Alliance
  - www.sustablebiodieselalliance.com

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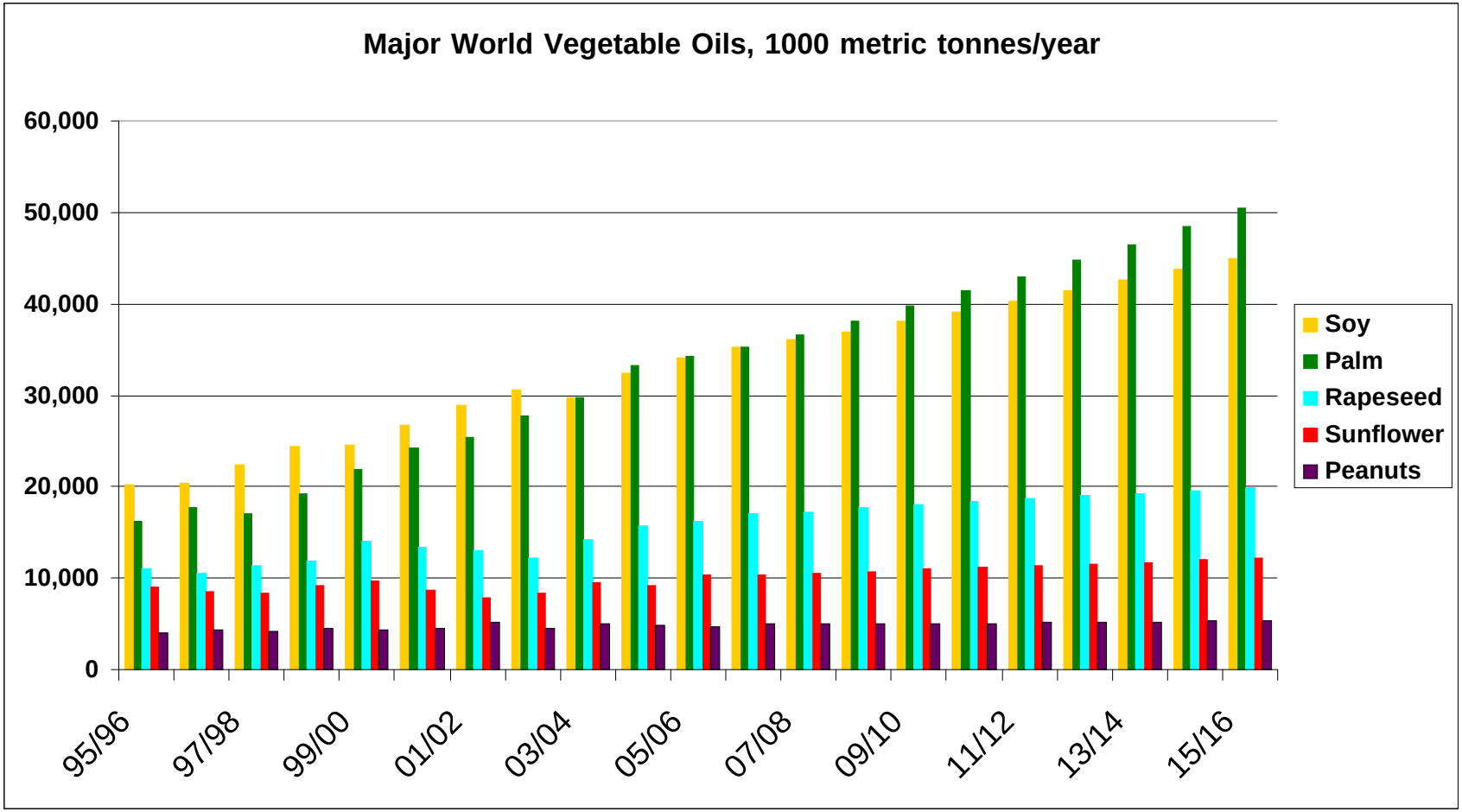
Sustainable Feedstock Issues

- Biodiversity conservation
- Soil quality & conservation
- Reduce GHGs
- Improve energy efficiency
- Water quality and conservation
- Reduce air pollution
- Minimize farm chemicals
- No or limited GMO
- Community involvement
- Protect farmer land rights
- Ensure fair commodity prices
- Ensure safety and health
- Ensure fair wages
- Expand local wealth & jobs
- Protect arable land
- Improve rural quality of life
- No risk to food security
- Improve farm productivity
- Expand food, fuel and fiber supply

Current World Oil Projections



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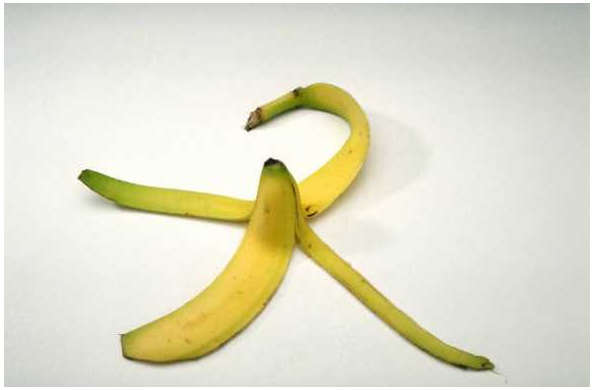
World Oilseeds and Products: FAPRI 2006 Agricultural Outlook
http://www.fapri.iastate.edu/models/oilseeds.aspx

Unintended Impacts



- Land Expansion Limits
  - Indonesia, Brazil
  - Protects Biodiversity
  - Reduces GHG emissions
- Puts more pressure on crop productivity improvements
  - GMO, chemicals, reduce crop varieties
- Increases food security risks
- Increases vegetable oil prices
- Reduces biodiesel expansion (prices, supply limits)
- Reduces fuel security, fuel diversity

New Oil Under Consideration

- Algae
- Bacteria, molds, fungus
- Borage
- Broomcorn
- Canola
- Camelina
- Castor beans
- Comfrey
- Corn (for oil)
- Cottonseed
- Crambe
- Cuphea
- Flax
- Guayule
- Industrial Hemp
- Jatropha
- Jojoba
- Kenaf
- Lesquerella
- Lupine
- Meadowfoam
- Milkweed
- Mustard
- Moringa
- Nuts: walnuts, almonds
- Perilla
- Palm
- Pumpkins, gourds
- Rapeseed
- Safflower
- Sesame
- Soybeans
- Sunflowers
- Vernonia

?

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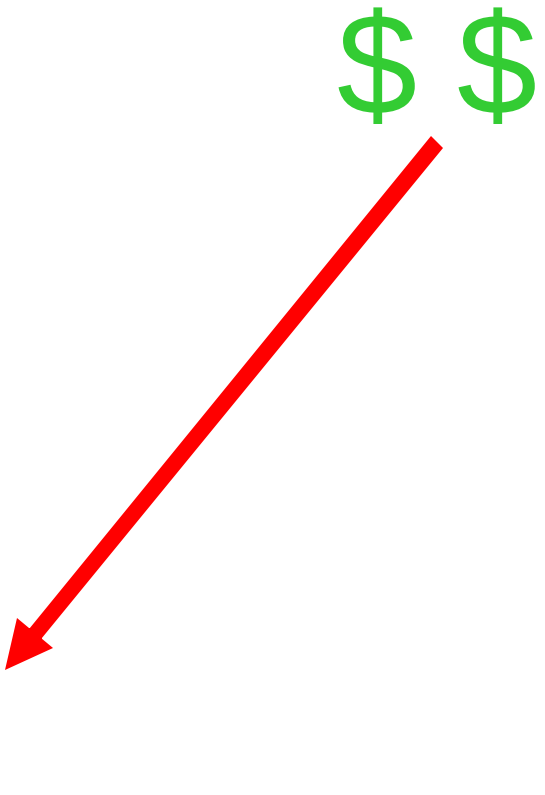
Oilseed Crops: Keys to Success

- Strong demand for oilseed products—meal & oil
- High prices for oilseed products—meal & oil
- Crushers margins are competitive and/or growing
- Crushers will pay good money for the seeds
- Farmer makes more profits than other crops
- Then the farmer will expand oilseed production
- Needs infrastructure, equipment, storage, …

- **The oil content of the seed is not generally the deciding factor**

Plant it and they will buy it?

- If the crusher doesn't like your seed, the farmer generates a loss
  - High anti-nutritional compounds
  - High transportation costs
  - High cost to test meal - feed trials
  - Low quality meal
  - High fiber
  - High segregation costs
  - Low quality oil
  - Poor quality seed
  - Poor seed handling practices



Sustainability Filter

- Jatropha
  - Claimed to be sustainable
- Moringa
  - Unknown crop
- Other Crops?

Jatropha

- Lots of varieties available
- 25-55% oil content
- 1.5-7.8 tonnes/ha seed
- 30-50% oil extraction
  - 13 – 250 g/A
- Sustainable Benefits?
  - Drought
  - Poor soils
  - No food competition

Hedgerow vs Plantations

Small holder, livestock hedge, Poor soils, limited water, limited fertilizer, low yields

Plantation, acres, displacing other crops, good soils, good water, sufficient fertilizer, high yields

Yield Improvements Underway

Typical fruit clusters

High yielding varieties

Need Harvesting Technology and/or Agronomic Improvements

Dried fruit clusters do not fall off

Fruits do not all mature at same time

Extraction Scale

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Concepts versus Reality

- Produced 5 tonnes/ha on barren land?
  - Sustainable: Most yields < 1 ton/A (1.5-2.5 tonnes/ha)
  - Good species selection is necessary for high yields
  - Large scale production is using arable land
  - Irrigation is necessary for high yields
  - Pruning is critical for high yields
  - Fertilizer is requires for at least first 2 years for high yields
  - High labor requirements

Jatropha “The Superfund Tree”

- EVERYTHING associated with the plant is TOXIC
  - Especially the seed meal and including the oil
- LOW-TOXIC species found in Mexico
  - Little R&D being invested
- Asian and African plantations are based on the toxic varieties
- Jatropha crushers as superfund sites?

Meal Toxicity Components

Component	Toxic variety	Low-toxic variety
Phorbolesters (mg/g kernel)	2.79	0.11
Total phenols (% tannic acid equivalent)	0.36	0.22
Tannins (% tannic acid equivalent)	0.04	0.02
Phytates (% dry matter))	9.40	8.90
Saponins (% diosgenin equivalent)	2.60	3.40
Trypsin inhibitor (mg trypsin inhibited per g sample)	21.3	26.5
Lectins (1/mg of meal that produced haemagglutination per ml of assay medium)	102	51

All data are on dry matter basis,
Source: Makkar *et al*. 1998

Meal Toxicity

- HUMAN and LIVESTOCK!!!!
- Ingestion risks
  - Vomiting and death
- Dermal risk
  - May increase risk of skin tumors with workers, handlers based on mice studies
  - 37% of mice in study lead to tumors
- Do Not Know Understand Variations in Risk-Elevated Compounds by Species Type, Type of Compounds, Compound Concentration, Impacts
- Do not have a viable large scale demand for meal

Meal Market Opportunities

- Provides meal byproduct for fertilizer (5-10% N)?
  - Commercial crushing has high transportation cost back to farmer
  - Farmer must pay for fertilizer if he cannot get meal
- Meal as an energy product?
  - No large scale investment identified
  - Meal value as energy may not justify crushing
- Detoxifying technology expensive, sophisticated

Detoxifying Meal

- Moist heat (steam and heat) to 121^{o}C
- For 25 minutes (deactive trypsin)
- Then irradiation at 10kGy to reduce phytate
- Then ethanol extraction to reduce saponin
- Followed by NaHCO3 to reduce lectin
- Do all the above and the phorbol esters can be reduced by 97.9%

Moringa Oleifera

- Africa, Asia S. America
- Fast growing, drought tolerant
- Needs good soil, water, fertilizer
- Perennial in Africa and India
- **Annual** cultivars being commercialized
  - May be developed for colder climates such as Southern US
  - Perennial in Florida, withstands mild frost

Looks like a locust tree

Moringa Oleifera: “Tree of Life”

- Immature pods sold for vegetables
- Leaves sold for salad
- Leaves sold for animal fodder
- Roots as condiment
- Bark & parts for pharmaceuticals
- Seeds produce oil and high protein meal
- Meal and leaves provide specialized infant amino acids: *argenine* and *histidine*
- Meal used to extract water purification additive
- Wood trimmings for poles, fencing, shelter
- Flowers for sale and honey production

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Moringa Drumsticks

- Similar to asparagus
- Immature pods sell as vegetables
- India: 52,000 farmers in 2001
- 33,353 hectares (80,280 acres) under cultivation
- Annual net income ~ $1500/h ($600/A)

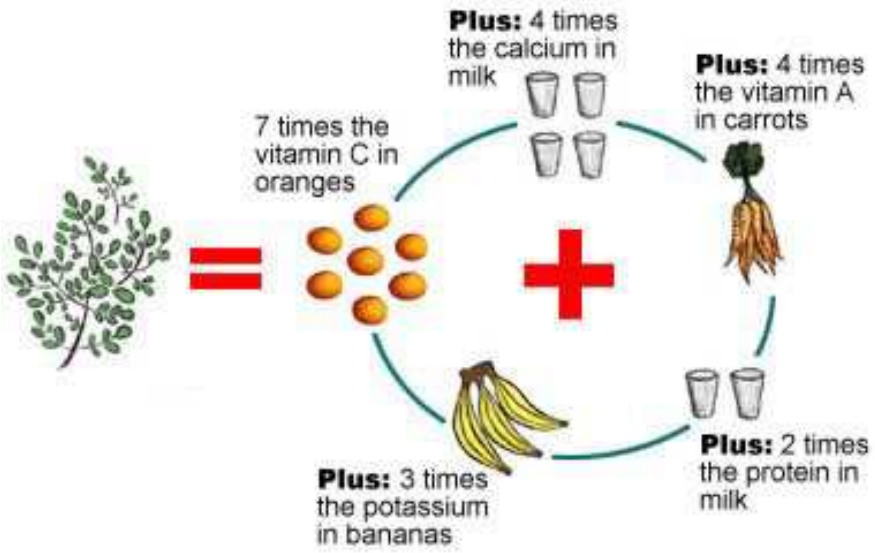
Pods are High Nutritional Food

- **All values are per 100 grams of edible portion**
  - Protein, 2.5g
  - Carotene, 110mcg
  - Fat, 0.1g
  - Minerals, 2.0g
  - Fiber, 4.8g
  - Carbohydrates, 3.7g
  - Calories, 26
  - Calcium, 30mg
  - Phosphorus, 110mg
  - Iron, 0.18mg

- **All values are mg per 100 grams of edible portion**
  - Magnesium, 28
  - Sodium, 0
  - Potassium, 259
  - Copper, 0.01
  - Manganese, 0.05
  - Zinc, 0.16
  - Chromium, 0.003
  - Chlorine, 423
  - Thiamine, 0.05
  - Riboflavin, 0.07
  - Niacin, 0.2
  - Vitamin C, 120

Leaves Sold for Salad & Vegetable

- Protein, 23%
- Highly digestible protein
- Contains all the essential amino acids needed for healthy humans.
- An excellent source of protein for vegetarians and those unable to produce enough livestock.



Moringa even contains *arginine* and *histidine*—
two amino acids especially important for infants.

High density leaf production

Vegetable Crop or as a Forage for Livestock

Cattle weight gain increased 32%

Milk production increased 43-65%

Leaf Extract: Crop Yield Enhancer

- Juice from fresh moringa leaves can be used to produce an effective plant growth hormone
  - Yield increases 25-30% for “nearly any crop…”
  - 100% Yield increases on corn claimed
- One of the active substances is Zeatin: a plant hormone from the Cytokinines group

Moringa Oil Production

- 3 tonne seed/hectare (1.37 ton/A)
- 30-40% oil content in seeds
  - 107-142 gal/A
  - 65-80% oleic acid
- Defatted meal contains 61% protein

Moringa Oil Fatty Acids

Fatty Acid		Composition %			
		NRI (1993)	Ferrao and Ferrao (1970)	Dahot and Memon (1985)	TEI (1995)
Myristic	C14:0	0.1	-	1.4	-
Palmitic	C16:0	5.9	6.7	3.5	6.9
Palmitoleic	C16:1	1.1	-	-	1.1
Stearic	C18:0	5.1	4.3	8.3	8.3
Oleic	**C18:1**	**72.9**	**76.5**	**67.3**	**67.7**
Linoleic	C18:2	0.6	0.7	3.5	0.4
Linolenic	C18:3	0.1	-	-	-
Arachidic	C20:0	3.6	2.7	2.7	4.7
Eicosenoic	C20:1	2.3	-	-	2.6
Behenic	C22:0	7.3	4.6	5.6	7.4
Lignoceric	C24:0	1.0	1.1	3.2	0.4

Michiru KHUMBO OIL REFINERY GROUP

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Important amino acids of seeds or parts (g / 16gN)

Amino acids	Soybean meal[b]	Jatropha seed meal[c]	Moringa leaves[d]	Moringa kernel meal[d#]
Methionine	1.22	1.76	1.98	1.90
Cystine	1.70	1.58	1.35	4.22
Valine	4.59	5.30	5.68	3.47
Isoleucine	4.62	4.85	4.50	3.05
Leucine	7.72	7.50	8.70	5.27
Phenylalanine	4.84	4.89	6.18	3.97
Tyrosine	3.39	3.78	3.87	1.50
Histidine	2.50	3.08	2.99	2.27
Lysine	6.08	3.40	5.60	1.47
Arginine	7.13	12.9	6.23	11.6
Threonine	3.76	3.59	4.66	2.25
Tryptophan	1.24	1.31*	2.10	NA

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[a] Adapted from Siddhuraju and Becker, 2001b
[b] taken from Hossain and Becker, 2001
[c] Taken from Makkar and Becker, 1999a; *value of toxic variety, other values of non toxic seeds
[d] From Makkar and Becker 1997c, [#] after oil extraction

Moringa Antinutrional Compounds

Substance	Leaves	Kernels	Fat free kernel meal
Total phenols (% tannic acid equivalent)	4.4	0.02	0.04
Tannins (% tannic acid equivalent)	1.2	ND	ND
Saponins (% diosgenin equivalent)	8.1	1.1	1.4
Phytate (% dry matter)	2.1	2.6	4.1
Lectins (1/mg of meal that produced haemagglutination per ml of assay medium)	ND	Variable (15/66.5/250)	Variable (15/66.5/500)
Cyanogenic glycosides (%)	ND	0.5	1.3
Glucosinolates (mmol/g)	ND	46.4	65.5

ND - not detected Source: Makkar and Becker 1997c.

Moringa Meal as Water Quality

- Seed meal purifies water
  - Large scale commercial test in Malawi
  - Flocculent for solids, aquatic organisms
  - Reduces turbidity and improve water quality
- The cationic polyelectrolyte has been extracted and may be marketed as a proprietary product under the name “Phytofloc”
  - Cheaper than using aluminum sulfate (alum)
  - 35 milligrams compared with 150-220 milligrams of seed meal

Moringa Production Issues

- Large species variations
  - Allows for large breeding potential, selecting locations
  - Need to explore new annuals
  - Need more pods per branch, more pod clustering
  - Need short bush varieties or pruning technology
- Mechanized harvesting and seed removal technologies needed
- Meal quality optimization approaches needed
- Livestock feeding trials needed

Sustainability Summary

- May have major impact on oil supply
- Should increase scrutiny
- Should be transparent
- Will require realistic trade offs
- May limit oil production
- We can find crops that produce food and fuel
- Sustainability filter cannot be simplistic

Contact Information

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